A new Cloud Base Calibration Technique and new Analyses from the GSFC Scanning Raman Lidar

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System Description

- *XeF excimer laser, 351 nm*
- *30-60 mJ per pulse, 400 Hz*
- *76 cm Dall-Kirkham telescope*

Collects backscatter from
- laser
- Raman-scattered oxygen
- Raman-scattered nitrogen
- Raman-scattered water vapor

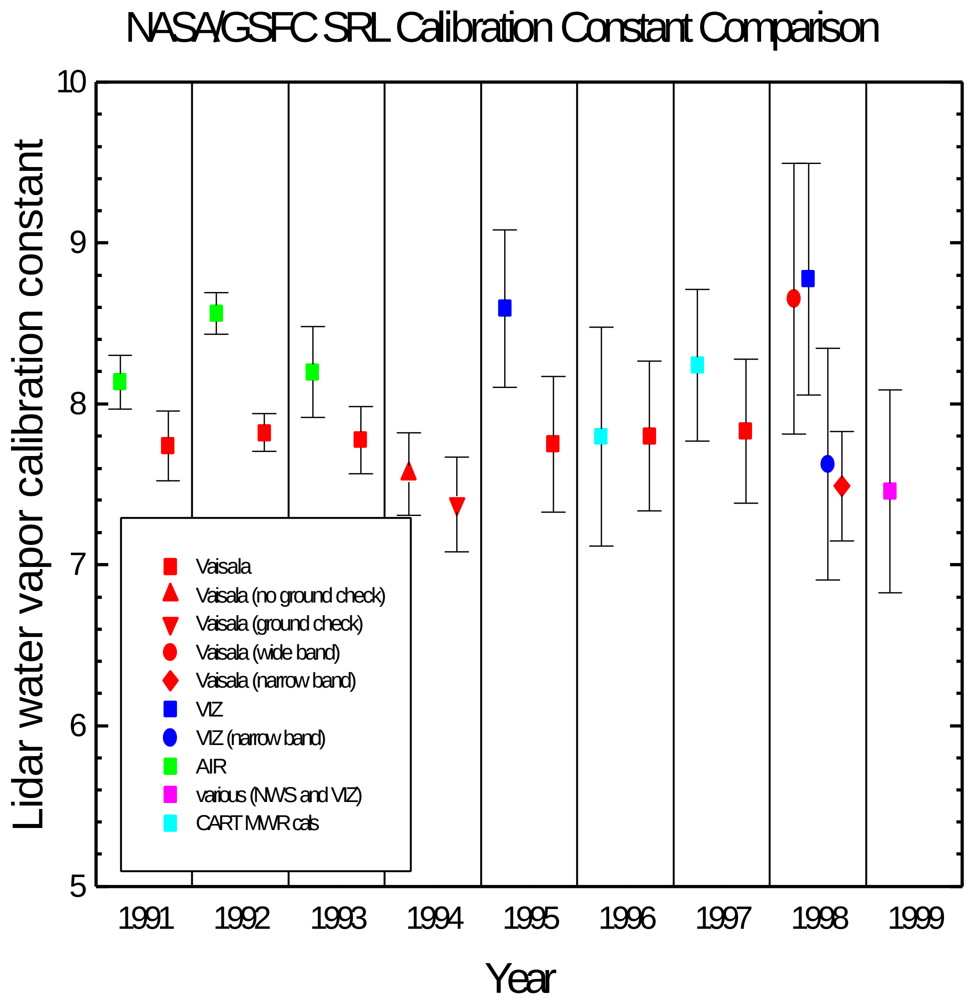
- *Low & high sensitivity channels*
- *1 minute profiles*
- *75 m vertical resolution*

Introduction

- *Scanning Raman Lidar (SRL) has been taking measurements for almost 10 years*
- *Radiosondes have been used for calibration regularly due to their availability and ease of use*
- *Other sensors could be used to calibrate the SRL, including using precipitable water vapor sensors*
- *A cloud base calibration technique that relies only on surface temperature and pressure (and a well-mixed assumption) and saturation at cloud base is presented here*
- *Sensitivity of the new algorithm is discussed*
- *A mid-tropospheric drying in front of Hurricane Bonnie is shown*

SRL System Calibration

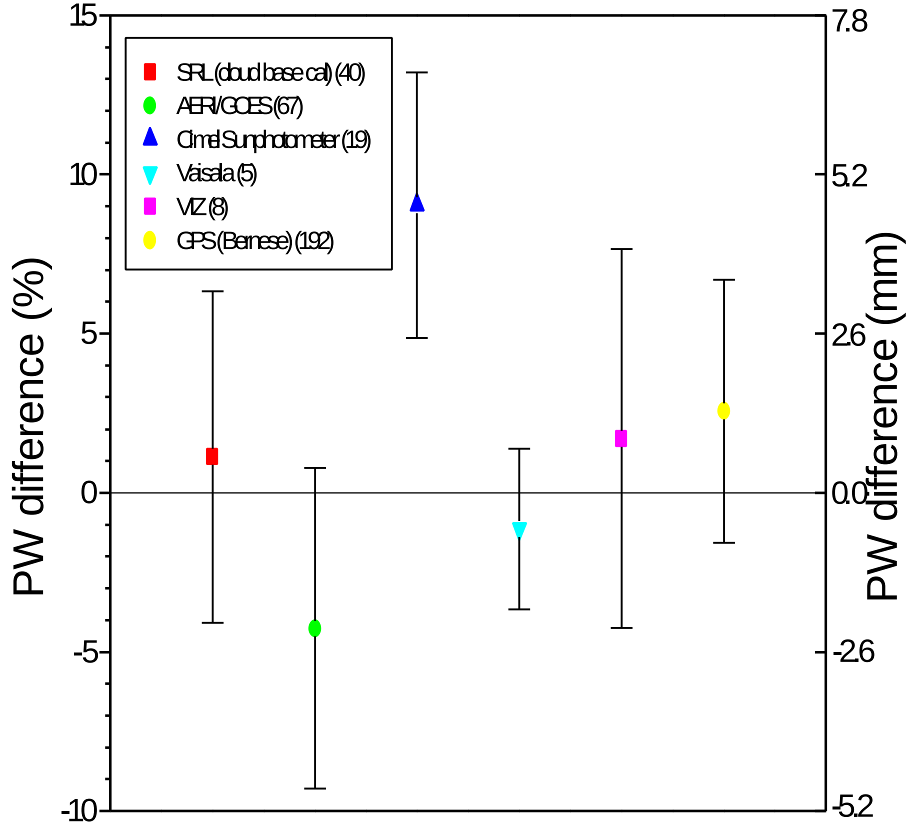
- *Over past 9 years, calibration has remained stable*
- *Modifications made often to improve measurements*
- *Between 1997-1998, major modifications done*
- *All calibrations within 15%*
- *Excluding 1998, Vaisala only cals within 5%*



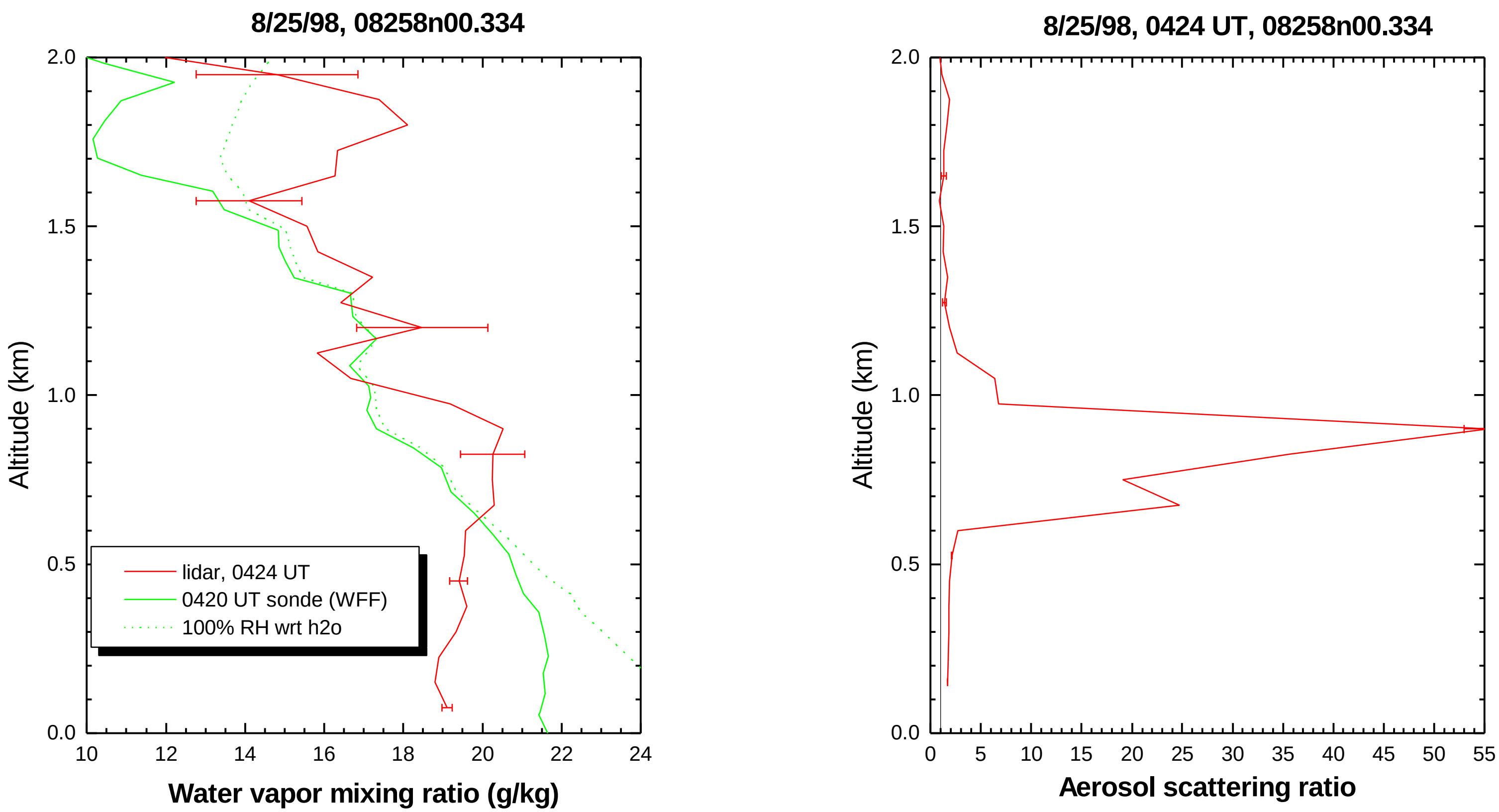
Precipitable Water Vapor Differences

Using GPS (GAMIT method) as a reference, differences in PW are shown for SRL, GPS (Bernese method), Cimel Sunphotometer, Vaisala and VIZ radiosondes, and AERI/GOES combined retrievals.

These data could be used to calibrate the SRL, but note the 5-10% differences.



Cloud Calibration Profiles



The left plot shows the SRL water vapor mixing ratio data compared to radiosonde data and its saturation value; the right plot is the SRL aerosol scattering ratio data. Cloud base is defined as the rise in the aerosol data at 0.600 km. Note supersaturation in water vapor data above 0.600 km.

Cloud Base Calibration Algorithm

•Without radiosondes

Using surface temperature and pressure measurements to derive cloud base temperature can be derived using the (dry adiabatic) lapse rate equation and the cloud base pressure can be derived from the hypsometric equation,given a surface pressure value. The only required assumption is that the boundary layer be well-mixed. Radiosonde data show this assumption to be a valid one. The cloud base water vapor mixing ratio are then obtained from the Clausius-Clapeyron equation

•With radiosondes

The cloud base water vapor mixing ratio are obtained from the Clausius-Clapeyron equation using the temperature and pressure obtained from radiosondes.

Sensitivity of Cloud Base Algorithm

1) *Computing saturation vapor pressure: since it's a nonlinear equation, used a range of temperatures*:

@ 16 ± 1 deg. C, e_s = 18.2 ± 1.2 mb (0.9 g.kg)

@ 23 ± 1 deg. C, e_s = 28.1 ± 1.7 mb (1.2 g/kg)

2) *Converting vapor pressure into water vapor mixing ratio*,

ΔP of ± 10 mb in atmospheric pressure
leads to ± 0.2 g/kg in mixing ratio

Calibration Comparison w/ & w/o Sondes

• *Without radiosondes*

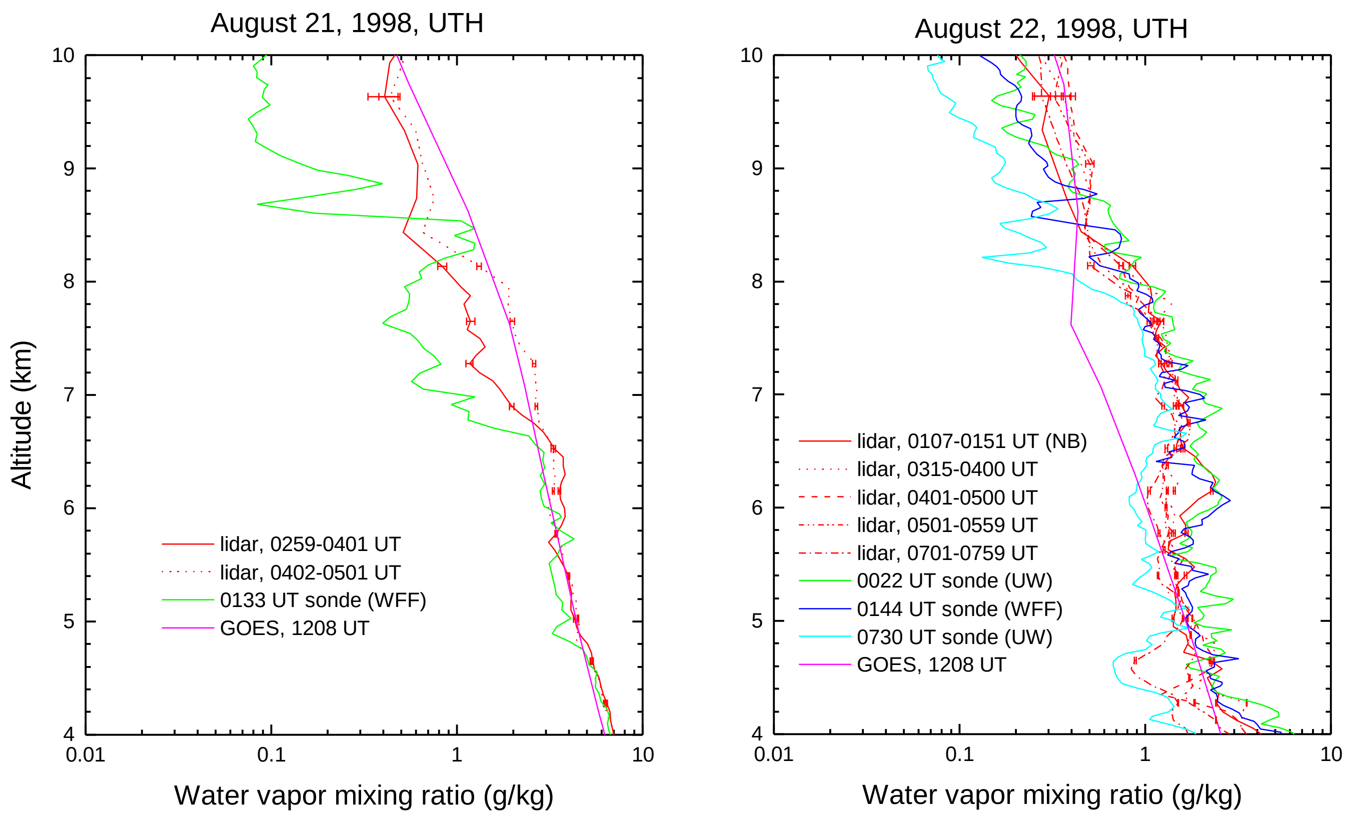
Using ground data from U of Wisc	21.50 ± 1.94	≈ -7.5%
Using ground data from Vaisala	21.36 ± 1.57	≈ -8.1%

• *With radiosondes*

Vaisala calibration	23.11 ± 1.24	≈ 0.0%
VIZ calibration	23.25 ± 1.85	≈ 0.6%
Radiosonde data at cloud base	23.12 ± 0.72	≈ 0.04%

Using radiosonde temperatures and pressures at cloud base is more consistent (note smaller error) and reliable (radiosonde temperatures are much more reliable than radiosonde water vapor mixing ratios).

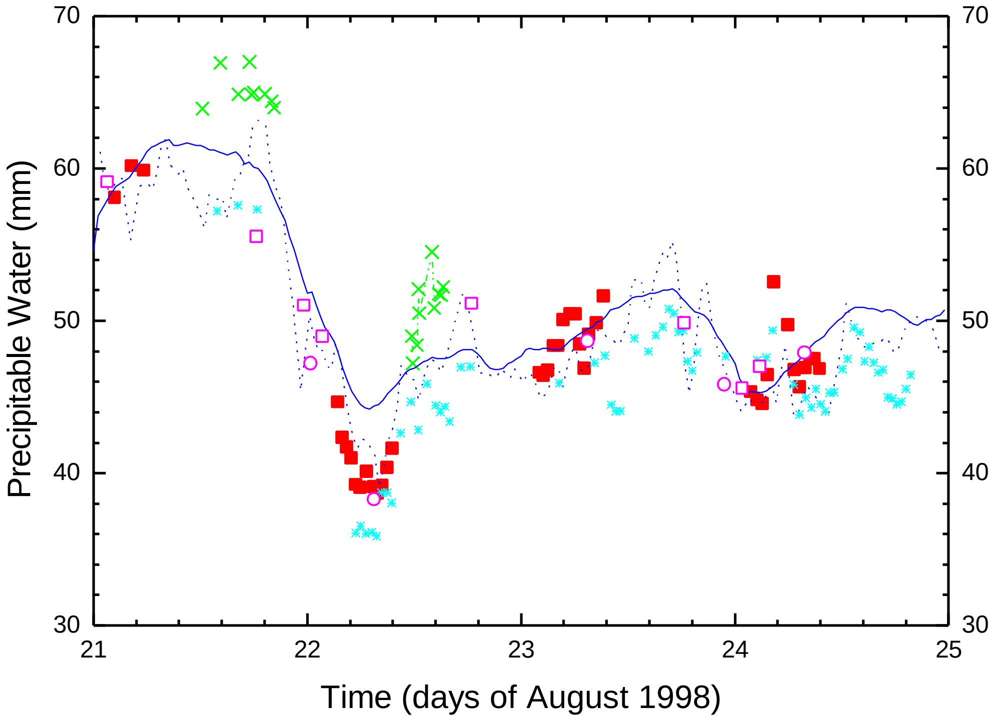
Upper Tropospheric Water Vapor



- *SRL upper tropospheric water vapor vs sonde and GOES data with sonde saturation mixing ratios*
- *Upper tropospheric water vapor is very important radiatively*
- *SRL and GOES agree, while sondes are drier than SRL and GOES*

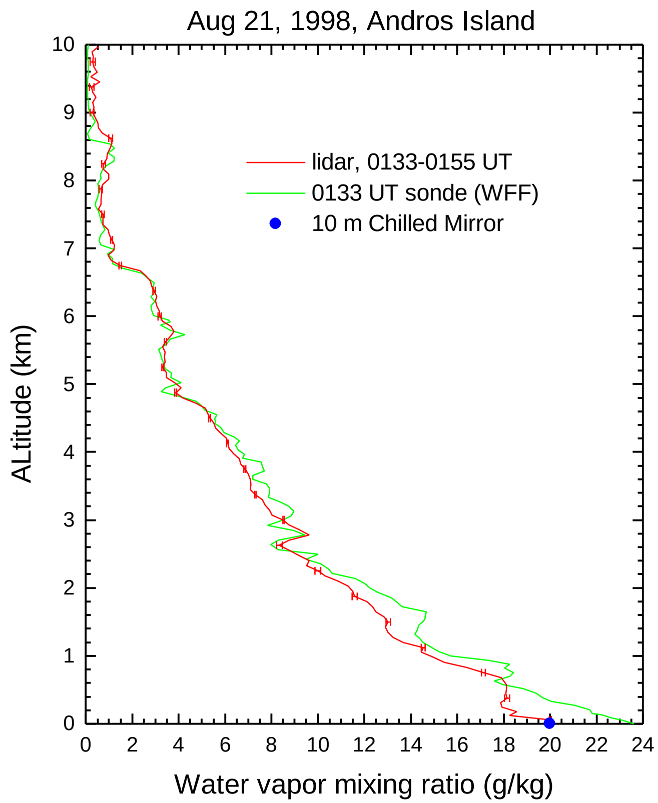
Precipitable Water Vapor Comparison

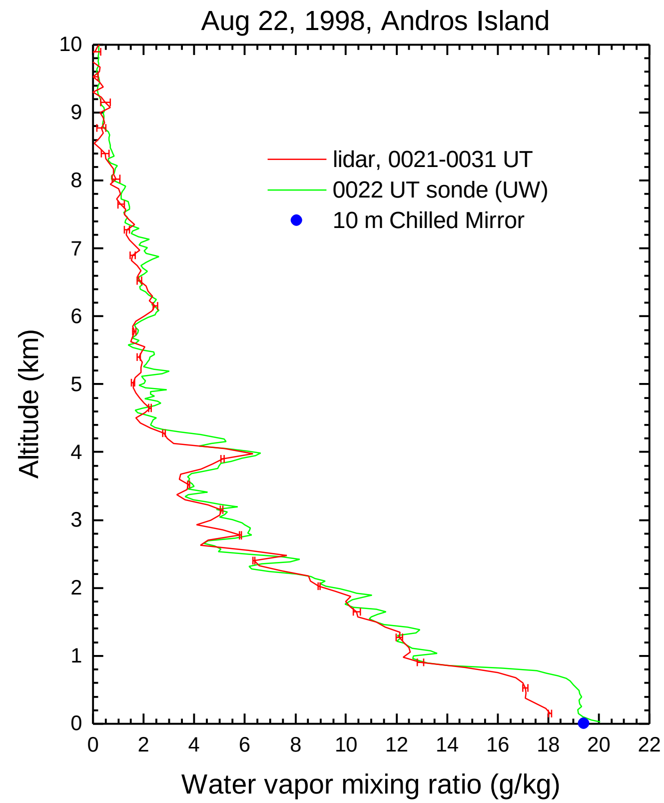
Instruments
•SRL w/ cloud base cal (red)
•AERI/GOES (cyan)
•Cimel sunphotometer (green)
•Vasaila (magenta sqaures)
•VIZ (magenta circles)
•GPS (GAMIT) (blue solid)
•GPS (Bernese) (blue dashed)



All instruments at Andros Island reflect the mid-tropospheric drying (shown as a decrease in precipitable water vapor) seen in the SRL data.

SRL-Radiosonde Comparisons





- *Profile comparisons with the 10 m U of Wisc chilled mirror*
- *Note how well the lidar structure matches the radiosonde structure*
- *Also, note the variability in the ground data between the 3 sensors*
- *The error bars are from Poisson statistics*

SRL and GOES Comparisons

- *SRL and GOES data for the nights of Aug 21-22, 1998*
- *Andros Island is situated in the center of the GOES images*
- *On 8/22, the white blob in the lower right hand corner is the western edge of Hurricane Bonnie*
- *Note the dark band to the west of Hurricane Bonnie on 8/22*
- *The SRL water vapor data show a mid-tropospheric drying on 8/22 as compared to 8/21*
- *The SRL data show the boundary layer to be consistent with a maritime boundary layer (winds were ESE, i.e., from the ocean)*

Summary and Conclusions

- *The cloud base calibration, derived from basic meteorology and surface measurements of temperature and pressure, is within the 5-10% accuracy of other instruments/methods*
- *Differences in surface temperature between the radiosonde and the ground station could account for the 8% calibration difference*
- *The SRL data show boundary layer convection at night due to the maritime influence*
- *The ensemble of instrumentatio on Andros Island show a mid-tropospheric drying due to Hurricane Bonnie*
- *The cloud base calibration technique using radiosonde temperatures and pressures at cloud base is more consistent and reliable than using ground data for the cloud base technique or using radiosondes water vapor data for calibration*